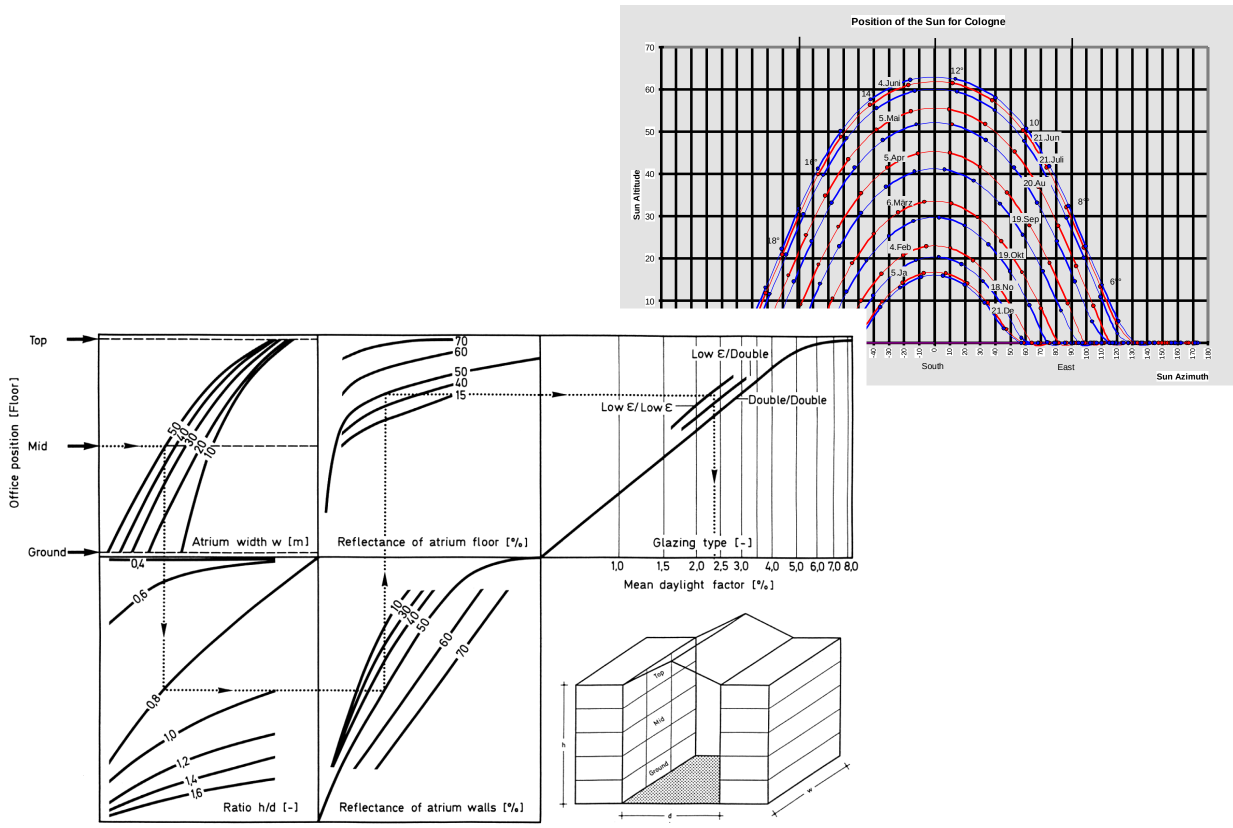
Survey
Simple Design Tools

A Report
of IEA SHC TASK 21 / ECBCS ANNEX 29
May 1999



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Survey Simple Design Tools

International Energy Agency (IEA)
Solar Heating and Cooling Programme Task 21 /

Energy Conservation in Buildings and Community Systems Programme Annex 29:

DAYLIGHT IN BUILDINGS

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PREFACE

The main objectives of the IEA Solar Heating and Cooling Programme (SHC) Task 21 and the Energy Conservation in Buildings and Community Systems Programme (ECBCS) Annex 29 "Daylight in Buildings" are to advance daylighting technologies and to promote daylight conscious building design. Task 21 continues until December 1999, and will endeavour to overcome the barriers that are impending the appropriate integration of daylighting aspects in building design. The participants in this task are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Netherlands, New Zealand, Norway, Sweden, Switzerland, United Kingdom and the United States. Denmark is the Operating Agent.

The objective of Subtask C "Daylighting Design Tools" of Task 21 is to improve the capability, accuracy and ease-of-use of daylighting design and analysis tools for building design practitioners, covering all phases of the design process. The practitioners will be able to predict the performance of different daylighting systems and control strategies and to evaluate the impact of the integration of daylighting in the overall building energy concept by using these design tools. Subtask C is devided into 5 Subgroups:

C1: Validation
C2: New Daylight Algorithms
C3: Integrated Systems
C4: Simple Design Tools
C5: ADELINE 3.0.

This "Survey on Simple Design Tools" was initiated and compiled within Subgroup C4.

EXECUTIVE SUMMARY

The document presents work conducted as part of Subtask C, ''Daylighting Design Tools", Subgroup C4, ''Simple Design Tools", of the IEA SHC Task 21 and the ECBCS Program Annex 29 ''Daylight in Buildings".

In addition to further developing and promoting powerful daylighting design tools, a major focus of Subtask C was on simple design tools. Complex simulations are often not appropiate to outline basic daylighting strategies in early design stages and to solve simple, frequently occuring problems (e.g. the sunshine duration at considered spots or a general decision about the type of rooflights to select), because it takes too much time to use them, i.e., they are not cost-efficient. This survey rather reviews a cross-section of various types of simple daylighting design tools and their different applicatons. This survey covers tools based on analytical solutions, tables, nomograms, diagrams, so- called protractors, simple computer tools, typological studies, as well as scale models. These tools provide support at various stages of the design process helping to determine the impact of the design on natural lighting conditions: building site and building layout planning (i.e. sunshine duration at considered spots, shadow and reflection analysis), typological support for the selection of a daylighting strategy, determination of the type and size of daylight openings and the corresponding daylight factors for differently daylit rooms, as well als ernergetic aspects of lighting design.

Besides a number of basic and already well-known tools, a couple of new design tools developed recently by institutes participating in the Task are included. To allow for problem-sensitive selection, the survey includes a table to characterise the reviewed tools.

CONTENTS

1 INTRODUCTION

Many problems in lighting design - artificial as well as daylighting - can nowadays be treated and solved with simulation software. Depending on the complexity of the problem, the stage of the building design process, the desired accuracy, as well as the quality of the output information, the application of more sophisticated tools is often the only way to pursue. Although these tools normally ask for detailed modelling, require a thorough knowledge of the programs, and demand high computational power, the modelling processes have been simplified over the last years, they still can be rather time-consuming.

Complex simulations are often not appropriate to outline basic daylighting strategies in early design stages and to solve simple, frequently occuring problems (e.g. the sunshine duration at considered spots or a general decision about the type of rooflights to select), because it takes too much time to use them, i.e., they are not cost-efficient.

The development of simple design tools has been, and still is, motivated by a number of reasons:

- Historically, due to the need to approach daylighting problems (without the support of computer technology being available), a number of simple tools, often closely tailored to practioner's needs has evolved. These tools deliver fast and generally sufficiently accurate results; most of them have been well-tested and validated.
- Simple design tools like tables, nomograms etc. are often the outcome of a ''knowlegde compression" from complex parametric studies. The required data are, for example, obtained from model studies under artificial skies or numerous computer program runs. The interdependence of design parameters can then quickly studied by for instance pursuing for atria design certain paths of boundary conditions in a nomogram, and then finally giving the daylight factors in the adjacent offices. These tools are based on extensive experience. The parametric variations do not need to be performed again by the user of the tools.
- With computers being available at almost every workplace, a number of simple computer tools were developed and are in use. Simple programs or simple parametric inputs to more sophisticated tools deliver fast solutions for specific problems while keeping modelling efforts and computation time limited. These are especially suited for performing simple variations of parameters (e.g. varying the window size and placement). The implementation of equations in spreadsheets and their ''display" in diagrams with programs like MS-EXCEL, is fast and convenient to use.

With hundreds of design tools existing in the field of daylighting, this survey does not and cannot attempt to cover all available and developed tools. Rather the survey is a collection of various types of tools and of the different fields of application. Tools based on analytical solutions, tables, nomograms, diagrams, so- called protractors, simple computer tools, typological studies, and also the method of using scale models are ing described. The tools provide support at the various stages of the design process helping to judge the impact of the design on natural lighting conditions: building site and building layout planning (i.e. sunshine duration at considered spots, shadow and reflection analysis), typological support for the selection of a daylighting strategy, determination of the type and size of daylight openings and the corresponding daylight factors for differently daylit rooms, as well as energetic and thermal aspects of lighting design.

The survey results are based on responses from a questionnaire distributed to the participants of IEA SHC TASK 21 /ECBCS Annex 29. In total 18 tools are presented and discussed in the survey, including several newly developed tools.

For a problem-sensitive selection of tools, the survey includes a table charaterizing the survey tools according to a set of attributes (requested input, obtainable output etc.).

2 REVIEWED TOOLS

Each tool is reviewed according to *Author/Source, Subject, Description, Discussion*, *Reference,* and *Example*. The *Description* part presents the method, requested input parameters, and obtainable output. In the tool *Discussion* general comments on the tools are given. Restrictions in the applications are pointed out. Some of the reviewed tools are for instance in the version, in which they are presented, only applicable under defined boundary conditions, i.e. certain sites and climates, or being subject to national regulations. Nevertheless, by being aware of these restrictions a simple transition to other conditions is in most cases possible.

Finally, for each tool an *Application Example*, containing examplarily solutions of equations, use of graphics or nomograms, excerpts of data tables, output from computer tools etc. is included. Hereby the specific features, the restrictions, as well as an impression of the time to apply a tool is conveyed.

For a fast selection of the tools reviewed, a classification according to *tool type* and to *tool subject* is included at the beginning of this section. The matrix allows for cross-referencing between *type* and *subject* of the reviewed tools, i.e for a chosen *type* the determination of the covered *subjects*, and vice versa. For a more detailled characterization refer to section 3.

TYPE	SUBJECT								TOOL
	Daylight Factor for Sidelit Rooms	Daylight Factor for Rooflit Rooms	Window Design	Rooflight Design	Atria Design	Energetic Behaviour / Daylight Autonomy	Shadow and Reflection Analysis / Sunshine Duration	Visual Comfort	
1. Formulae f(x)		■		■					2.1.1
	■	■	■	■					2.1.2
2. Tables	■		■						2.2.1
		■		■					2.2.2
3. Nomograms	■	■	■	■	■				2.3.1
	■				■				2.3.2
4. Diagrams	■	■	■	■		■	■	■	2.4.1
	■		■						2.4.2
						■			2.4.3
						■			2.4.4
5. Protractors	■	■	■	■					2.5.1
6. Computer Tools	■	■	■	■		■	■		2.6.1
							■		2.6.2
							■		2.6.3
						■			2.6.4
	■	■	■	■		■			2.6.5
7. Typology	■	■	■	■			■	■	2.7.1
8. Scale Models 1:X	■	■	■	■	■		■	■	2.8.1

2.1.1 SKYLIGHT DIMENSIONS

Author / Source
German Industrial Standard, DIN 5034

Subject
Simplified determination of suitable rooflight dimensions for a given mean daylight factor.

Description
For a given mean daylight factor this method calculates from
1. the reflectances of the room surfaces,
2. the room dimensions,
3. the glazing parameters (transmission, framing factor, and dirt-on-glazing factor),
4. and the type of rooflight with the geometric parameters of the light wells

the necessary total rooflight area. From this total area and the number of desired rooflights, the depth as well as the width of the single rooflights can be determined. Among the five types of supported rooflights are saddle rooflights, 60° as well as 90° roofmonitors.

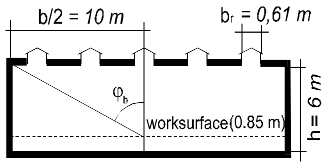
Discussion
Due to a simple characterisation of different rooflights, the method allows for a quick comparison of different rooflight types in the early design phase. Since it assumes a number of simplifications and is partly based on fixed parameters, certain restrictions in the accuracy of the results apply. The influence of interreflections from the room's side walls is for instance neglected. Since the tool is based on a free selectable daylight factor, the method can easily be applied for other than German conditions. It is limited to rectangular floor plans.

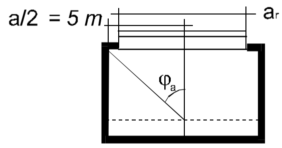
References
- German Industrial Standard, DIN 5034, *Daylight in Interiors, part 6, Simplified determination of suitable dimensions for rooflights,* DIN, Deutsches Institut für Normung e. V., 1996.

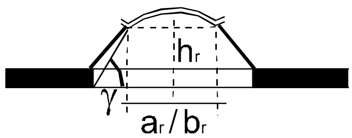
Application Example

The tool requires a set of geometric parameters defining a shoebox-type space. Examplarily values are printed in italics:

Section 1	Section 2	Standard Rooflight







The rooflight geometry is described according to the selected type, here a standard rooflight. Corresponding descriptions are available for other rooflight types.

From the following input parameters

Parameter	Description	Examplary Value
k_1	Framing factor, accounting for structural rooflight elements:	***0.8***
k_2	Dirt-on-glazing factor:	***0.8***
k_3	Factor for not normal light transmission from the sky:	***0.85***
k_4	Factor for geometric shape and reflection of rooflight well:	***0.92***
τ_{D65}	Transmission of rooflight glazing:	***0.6***
ρ_D	Reflection of light well:	***0.55***
ρ_C	Reflection of the ceiling:	***0.7***
ρ_F	Reflection of the floor:	***0.2***
ϑ_a	Factor accounting for finite room width geometry f(φ_a):	***0.76***
ϑ_b	Factor accounting for finite room length geometry f(φ_b):	***0.88***

the necessary total rooflight area *A* (work measurement) to get a required mean worksurface daylight factor of for instance $\overline{D}$ = ***5 %*** is obtained by the formula

$$A = \frac{\overline{D} \cdot a \cdot b}{\tau_{D65} \cdot k_1 \cdot k_2 \cdot k_3 \cdot k_4 \cdot \vartheta_a \cdot \vartheta_b \cdot 100} \cdot (1 - \rho_F \cdot \rho_C) = \boldsymbol{42.6\ m^2.}$$

From the area *A* with a given number *n* of desired rooflights the length a_r and width b_r of the single rooflight can be determined:

Number of Rooflights	Desired Width	Resulting Length
n = 10	b_r = 0.61 m	a_r = A/(n*b_r) = 7 m

2.1.2 DAYLIGHT FACTOR, INTERNAL REFLECTED COMPONENT

Author / Source

German Industrial Standard, DIN 5034

Subject

Internal reflected component of the daylight factor for side- and rooflit rooms.

Description

The daylight factor can be separated into three components: the direct sky component D_{sky}, a component caused by the visible part of outside obstructions $D_{obst.}$ and an internally reflected component D_{refl} : $D = D_{sky} + D_{obst} + D_{refl}$. The direct component can be obtained with a variety of tools (BRE daylight factor protractors → tool 2.5.1, Waldram diagrams → tool 2.4.2, etc.).

The equation given for the computation of the internal reflected component accounts for the luminous flux (separate angular description for the flux share above the outdoor obstruction and a share resulting from reduced luminances caused by the obstruction itself), window size, room surface area and corresponding mean reflection coefficients. The basic method accounts for the raw window opening. For the selected window embedded in the opening the obtained D_{refl} is weighted with glazing parameters (i.e light transmission, dirt-on-glazing factor, etc). The method is suited for windows in more than one wall. A simplified version exists for rooflit rooms.

Discussion

In contrast to the determination of the direct sky components this equation can only provide a mean daylight factor component. For investigated spots behind one half of the room depth the used mean reflection coefficients have to be substituted by the room‘s minimum reflection coefficient. The angular obstruction description can handle only obstructions that are even. For strong variations in the masking geometry mean angular values have to be used. There might be cases where this averaging does not lead to sufficient results.

References

- German Industrial Standard, DIN 5034, *Daylight in Interiors, part 3, Calculation, Calculation of the indirect component of the daylight factor,* DIN, Deutsches Institut für Normung e. V., 1996.
- Udo Fischer, *Tageslichttechnik,* Verlagsgesellschaft Rudolf Müller GmbH, Köln, 1982.

Application Example

From the following input parameters

Parameter	Description	Examplary Value
$\Sigma\, b_F\, h_F$	Sum of window area (here: height 1.7 m, width: 2.2 m)	***3.74 m²***
A_r	Sum of room surface areas (here: height: 2.5 m, width: 4 m, depth: 3.5 m)	***65.5 m²***
ρ	Mean Reflectance of all wall surfaces	***0.45***
ρ_{fw}	Mean Reflectance of floor and lower parts of the walls without wall containing window	***0.4***
ρ_{cw}	Mean Reflectance of ceiling and upper parts of the walls without wall containing window	***0.6***
α	Obstruction angle	***0°***
$f_u(\alpha)$	Window factor, function of the external luminous flux incident onto the window from the upper hemisphere, dependent of obstruction angle α	***0.319***
$f_l(\alpha)$	Window factor, function of the external luminous flux incident onto the window from the lower hemisphere, dependent of obstruction angle α	***0.067***

The internal reflected component of the daylight factor is obtained by the formula:

$$D_{refl.} = \frac{\sum b_f h}{A_r} \bullet \frac{1}{1-\rho} \bullet (f_u \cdot \rho_{fw} + f_l \cdot \rho_{cw}) \bullet 100\% = \mathbf{1.74\ \%}$$

2.2.1 MINIMUM WINDOW SIZES FOR DWELLINGS

Author / Source
German Industrial Standard, DIN 5034

Subject
Simplified determination of minimum window sizes for dwellings.

Description
Applicable to rooms daylit from one vertical, rectangular window this method provides the minimum window size in order to obtain a mean daylight factor of 0.9 % on the axis in the middle of the room (room depth) at an height of 0.85 m.
Depending on 4 parameters:

Linear outside obstruction (angular range):	0°- 50°
Height of the room: with a corresponding varying window height:	2.4 m - 3 m 1.35 m - 1.85 m
Room width:	2 m - 8 m
Room depth:	3 m - 8 m

the necessary window width is provided in tabular form. The minimum window width is assumed to be 55 % of the room width (corresp. to German regulation).

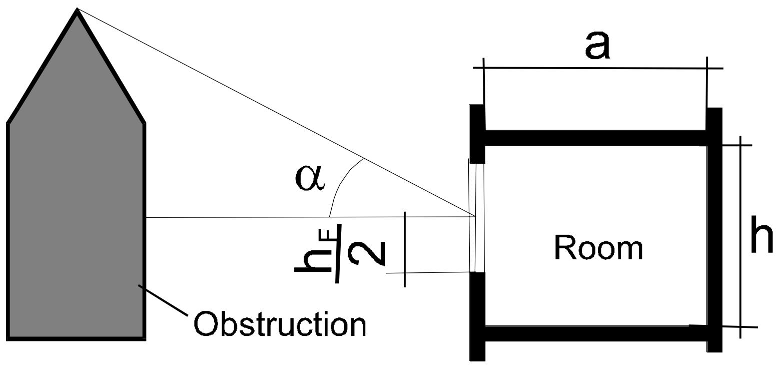
Discussion
Many design parameters like wall reflectances, glazing characteristics, height of the window sill, and the geometrical shape of an obstruction are fixed. The method is based on a daylight factor which has been found sufficient for German conditions. It is thus only suited for countries with similar geographic and climatic conditions. Nevertheless, recommendations for minimum window sizes are common in other countries. National lighting societies (or similar organisations) should be consulted.

References

- German Industrial Standard, DIN 5034, *Daylight in Interiors, part 4, Simplified determination of window sizes for dwellings,* DIN, Deutsches Institut für Normung e.V., 1994.

Application Example

Room Section with Angular Description of Obstruction



Examplary table: obstruction angle, α = 30 °; room height, h = 2.7 m; window height, h_F = 1.55 m

α	h	b	Minimum Window Width b_w for a given Room-Depth a																		
			3,00	3,25	3,50	3,75	4,00	4,25	4,50	4,75	5,00	5,25	5,50	5,75	6,00	6,25	6,50	6,75	7,00	7,50	8,00
30	2,70	2,00	1,31	→				1,31	1,34	1,51	1,61	1,69	1,78	1,86	1,95						
	(h_F=	2,50	1,64	→					1,64	1,75	1,86	1,96	2,06	2,16	2,26	2,36	2,45				
	1,55)	3,00	1,97	→					1,97	1,98	2,11	2,22	2,34	2,46	2,57	2,68	2,79	2,91			
		3,50	2,2	→						2,30	2,37	2,50	2,63	2,76	2,89	3,01	3,14	3,27	3,40		
		4,00	2,63	→						2,63	2,64	2,78	2,93	3,07	3,21	3,36	3,50	3,64	3,78		
		4,50	2,96	→							2,96	3,07	3,23	3,38	3,54	3,70	3,85	4,01	4,17	4,48	
		5,00	3,29	→							3,29	3,37	3,54	3,71	3,88	4,05	4,22	4,39	4,56	4,90	
		5,50	3,62	→							3,62	3,68	3,86	4,04	4,22	4,40	4,59	4,77	4,96	5,33	
		6,00	3,94	→							3,94	4,00	4,19	4,38	4,57	4,77	4,96	5,16	5,36	5,76	
		6,50	4,27	→							4,27	4,32	4,52	4,72	4,93	5,14	5,34	5,55	5,77	6,20	
		7,00	4,6	→							4,60	4,86	4,86	5,07	5,29	5,51	5,73	5,95	6,18	6,63	
		7,50	4,93	→							4,93	5,20	5,20	5,43	5,65	5,88	6,12	6,35	6,59	7,07	
		8,00	5,26	→							5,26	5,55	5,55	5,78	6,02	6,27	6,51	6,76	7,01	7,52	

For a linear horizontal outside obstruction seen under an angle of **30°** from the window pane, a room height of **2.7 m**, a window height of **1.55 m**, a room width of **5.5 m**, and a room depth of **6.0 m** a minimum window width of **4,22 m** is required. The obtained window size is a minimum requirement providing a mean daylight factor of **0.9 %** on an axis in half the room depth.

2.2.2 DAYLIGHT FACTOR FOR ROOFLIT SPACES

Author / Source

German Industrial Standard, DIN 5034

Subject

Determination of mean daylight factors in rooms with rooflights.

Describtion

The tool is based on the utilization factor method known from artificial lighting. For different combinations of room index (i.e. function of room height, depth, and width) and the reflectances of room surfaces the utilization factor for two different types of rooflights can be obtained from tables as functions of a set of geometric parameters:

Standard Rooflights	Shed Rooflights
Incline of rooflight wells (30°, 60°,90°),	Size of rooflight opening
Ratio depth to width and ratio height to width	Incline of non-glazed shed side
The resulting well index	Incline of glazed side.

The mean daylight factor is then calculated as a function of the determined utilization factor.

Discussion

The method delivers only mean daylight factors. Values for single points cannot be obtained. The tables allow for useful variations of design parameters for two very common rooflight types. The method is not restricted to German conditions. Recommendations for daylighting with rooflights are common in other countries. National lighting societies (or similar organisations) should be consulted for existing similar methods.

References

- German Industrial Standard, DIN 5034, *Daylight in Interiors, part 3, Calculation,* DIN, Deutsches Institut für Normung e. V., 1994.

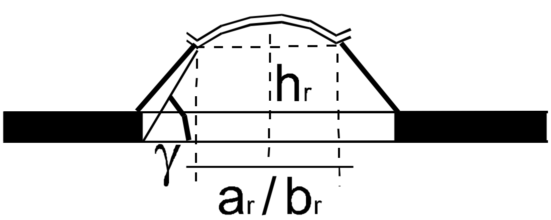
Application Example

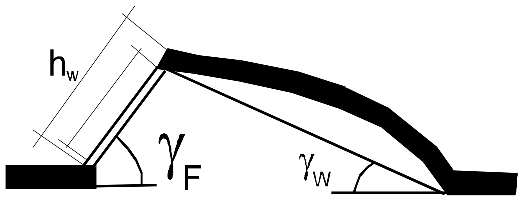
For a room length $a = \mathbf{20\ m}$, width $b = \mathbf{10\ m}$, height $h = \mathbf{5.30\ m}$ the room index is obtained:

$$k = \frac{b \cdot a}{h \cdot (b+a)} \approx \mathbf{1.25}\ .$$

The method can cope with two rooflight types. Type A is selected for this example.

Type A, Standard Rooflight	**Type B, Shed Rooflight**





The utilisation factor η[%] is determined from tables as a function of reflection coefficients, obtained room index k, and the rooflight geometry: η ***= 68 %.***

Examplary Table: η (utilization factor) in % for a_r / b_r = 1; h_r / b_r = 0,25; γ = 90°, w = 0,25

ρ_D	0,8	0,8	0,8	0,5	0,5	0,8	0,8	0,8	0,5	0,5	0,3	0
ρ_W	0,8	0,5	0,3	0,5	0,3	0,8	0,5	0,3	0,5	0,3	0,3	0
ρ_B	0,3	0,3	0,3	0,3	0,3	0,1	0,1	0,1	0,1	0,1	0,1	0
k												
0,6	64	40	32	38	26	49	38	31	36	26	23	16
0,8	75	53	44	50	37	57	49	42	48	36	32	24
1,0	81	59	50	55	41	60	54	47	52	40	35	27
1,25	88	68	59	64	49	65	62	56	60	47	41	32
1,5	93	74	66	69	54	68	67	61	65	51	45	36
2,0	98	83	75	77	61	71	74	69	71	57	51	40
2,5	102	88	81	81	65	73	78	73	75	61	54	43
3,0	104	92	86	85	68	75	81	77	78	63	56	45
4,0	107	98	93	89	73	76	85	81	82	67	59	48
5,0	109	101	97	92	75	77	87	84	84	69	61	49

A so-called 'outside daylight factor' $D_{out} = E_{plane} / E_{ext}$ (ratio of illuminance on inclined planes to horizontal external illuminance under a CIE overcast sky) is determined:
$D_{out} = \mathbf{1}$, for the here chosen standard rooflight type. With a planned total area of ceiling openings (work measurement) $A = \mathbf{45\ m^2}$ and additional parameters: glazing transmission $\tau_{D65} = \mathbf{0.6}$, framing factor $k_1 = \mathbf{0.8}$, dirt-on-glazing factor $k_2 = \mathbf{0.8}$, correction factor for not normal light penetration from the overcast sky onto the glazing pane $k_3 = \mathbf{0.85}$, and the total area of room surfaces $A_{surf} = \mathbf{200\ m^2}$, the mean daylight factor for this test room is obtained:

$$\overline{D} = D_{out} \cdot \tau_{D65} \cdot k_1 \cdot k_2 \cdot k_3 \cdot \frac{\sum A}{A_{surf}} \eta \cdot 100\% = \mathbf{5\ \%}$$

2.3.1 DAYLIGHT FACTOR, INTERNAL REFLECTED COMPONENT

Author / Source

R.G. Hopkinson, J. Longmore, P. Petherbridge

Subject

Nomogram for the determination of the internal reflected component of the daylight factor.

Description

The daylight factor can be separated into three components: the direct sky component D_{sky}, a component caused by the visible part of outside obstructions D_{obst} and an internally reflected component D_{refl}:

$$D = D_{sky} + D_{obst} + D_{refl} .$$

The direct component and the component from possible obstructions can be obtained with a variety of tools (BRE daylight factor protractors → tool 2.5.1, Waldram diagrams → tool 2.4.2, etc.). This tool is based on a nomogram derived from a simple equation in which the daylight factor's internal reflected component is calculated as a function of the size of the window opening, the total room surface areas, an utilization factor (known from artificial lighting calculations), which accounts for the surface reflections and surface ratios, as well as an outside obstruction angle. The utilization factor can be obtained from a separate chart. For a specified window embedded in the daylight opening (work measurement) the obtained D_{refl} is weighted with the window parameters (i.e. light transmission, dirt-on-glazing factor, etc.).

Discussion

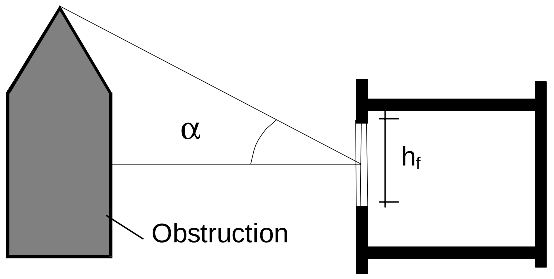
In contrast to the determination of the direct sky component, the nomogram can only provide a mean daylight factor component. Only simple linear obstructions can be handled; for bigger variations in the obtructions' geometry mean angular values have to be taken. The remaining components, df_{sky} and df_{obst}, have to be calculated using other methods. With nomograms of this type it is possible to treat vertical, tilted, and horizontal glazing layers (therefore also rooflights). Furthermore nomograms for the internal reflected component exist, which allow to analyse clear skies.

References

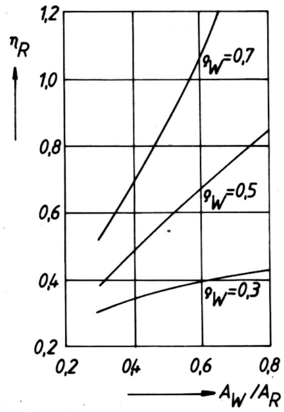
- R.G. Hopkinson, J. Longmore, P. Petherbridge, ''An Empirical Formula for the Computation of Indirect Component of the Daylight Factor'', Trans. IES, vol. 19, No. 7, 1954.
- Udo Fischer, *Tageslichttechnik,* Verlagsgesellschaft Rudolf Müller GmbH, Köln, 1982.

Application Example:

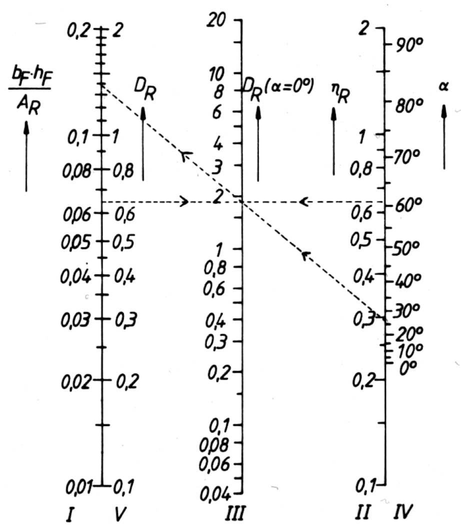
Obstruction Geometry



Utilization factor η_r chart



Nomogram for internal reflected component of the daylight factor



A path for an examplarily room geometry (total surface area A_R), window (width b_f and hight h_f), utilization factor (η_r, function of the surface ratio and reflectance ρ_W, as shown in graphic above), and an outdoor obstruction (seen under an angle α) is shown. The internal reflected component can be obtained directly from the nomogram for the case with obstruction as well as without obstruction.

2.3.2 ATRIUM LAYOUT

Author / Source
M. Szerman, Fraunhofer Institute for Building Physics

Subject
Nomogram for daylight factors in offices adjacent to atria.

Description
This tool provides a fast estimation of the mean daylight factors in rooms adjacent to linear atria. For a fixed office geometry (window / facade ratio 60 %, width: 3.5 m, depth: 4.8 m, and height: 2.7 m) and fixed reflectances of the office surfaces (floor: 15 %, walls: 50 %, and ceiling: 70 %) mean daylight factors can be obtained graphically for a range of atrium design parameters:

Office position:	Ground , middle, or top floor
Ratio of atrium height to depth	0.4 - 1.6
Reflectance of opaque atrium walls:	0 % - 70 %
Reflectance of atrium floor:	15 % - 70 %
Glazing of atrium:	Double / Low ε
Glazing of offices:	Double / Low ε

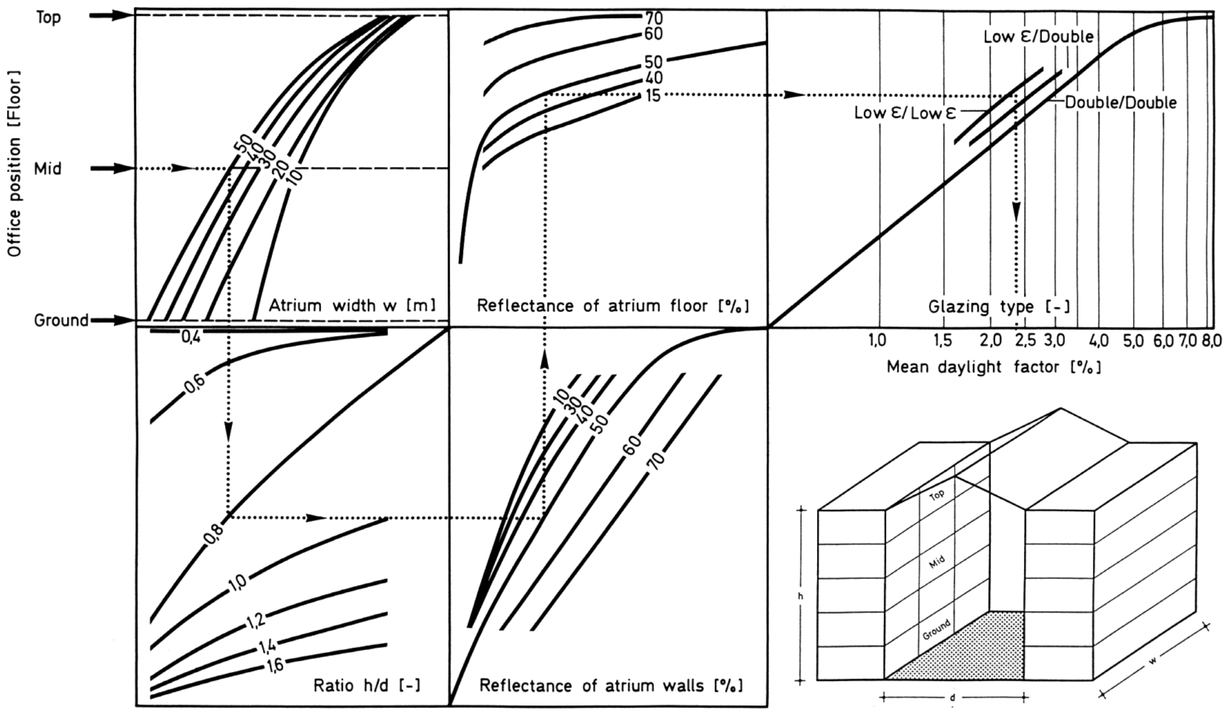
Discussion
The tool is a single stage method limited to linear atria. It delivers only mean daylight factors for the considered office spaces. Nevertheless it is an easy to handle tool to quickly understand the influence of decisive atria design parameters on lighting situations in connected workspaces. The data base used to generate the nomogram was obtained from scale model measurements under an artificial sky.

References

- *Passive Solar Commercial and Institutional Buildings, A Sourcebook of Examples and Design Insights*, International Energy Agency, Paris, France, John Wiley & Sons Ltd., 1994

Application Example

Nomogram, with exemplarily path and graphic showing the atria geometry



For a given set of design parameters:

Office Position:	***Middle***
Atrium Width, *w*:	***50 m***
Atrium Height, *h*:	***12 m***
Atrium Depth, *d*	***15 m***
Refl. Atrium Walls:	***50 %***
Refl. Atrium Floor:	***50 %***
Glazing Atrium:	***Low ε***
Glazing Office:	***Low ε***

A mean daylight factor of **2.4 %** in the considered office is obtained by following the specified path through the nomogram.

2.4.1 HORIZONTOSCOPE: SUNSHINE DURATION etc.

Authors:
F. Tonne

Subject
Determination of sunshine duration, direct sky component of the daylight factor, heat penetration.

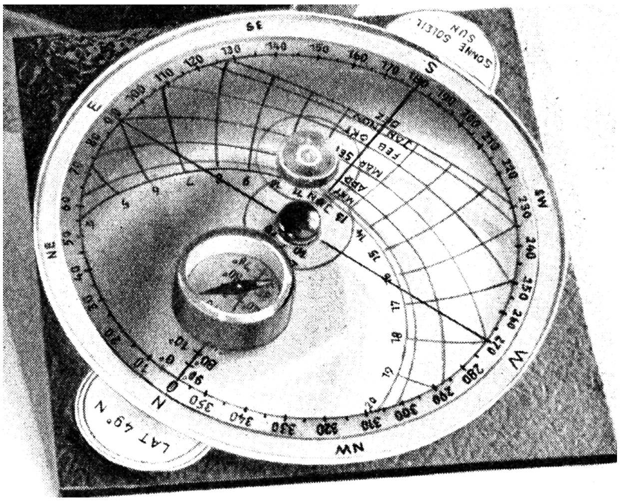
Description
The horizontoscope (a small acryl glass half dome with integrated compass) with a corresponding stereographic projection of the sun altitude and azimuth angle is applied for the on site determination of sunshine duration at selected outdoor or indoor spots. The standard sun path diagrams, available for all locations of uneven site latitudes, contain paths for summer and winter solstice, equinox, and average summer and winter days. Sunshine durations are obtained from the charts by evaluating hourly intervals which are lying in the projection of the free, not occulted sky segments. In the design phase the acrylic halfdome of the horizontoscope can be substituted by a geometrical projection of the daylight opening into another type of chart which is then superimposed onto the sun path diagram. The tool is able to account for any type of obstructions. Other available charts allow for the determination of the direct sky component of the daylight factor and for the quick assessement of possible glare sources. Heat charts can be used for quick estimations of solar heat penetration in indoor spaces as function of facade orientation, facade incline, and used glazing.

Discussion
Useful tool for the quick on site and designing phase estimation of the sunshine duration. Estimations of the daylight factors takes only the direct component into account. The internal reflected component has to be calculated using other methods (equation → tool 2.1.2, interreflected component nomograms → tool 2.3.1). For the use of the heat charts units have to be converted to SI units. The suggested glazing parameters have to be crosschecked with data of glazings used nowadays.

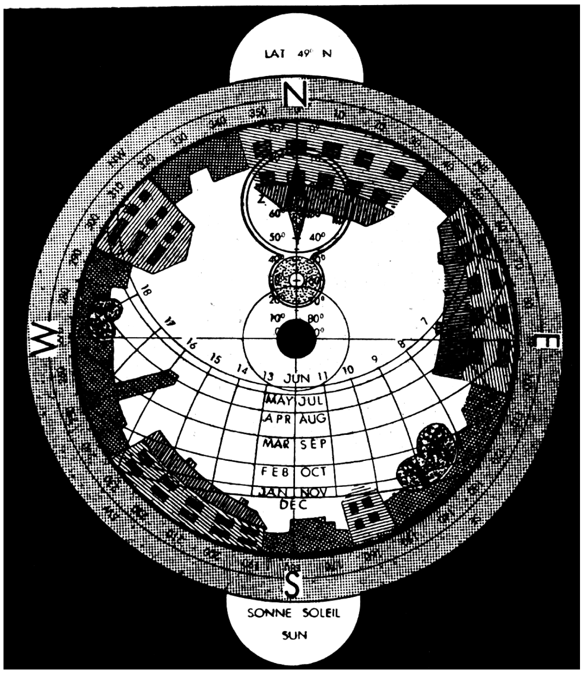
References
- Developed by F. Tonne. The tool is still distributed by the Institut für Tageslichttechnik, Eichgehrenweg 3, Stuttgart-Rohr, Germany.

Application Example

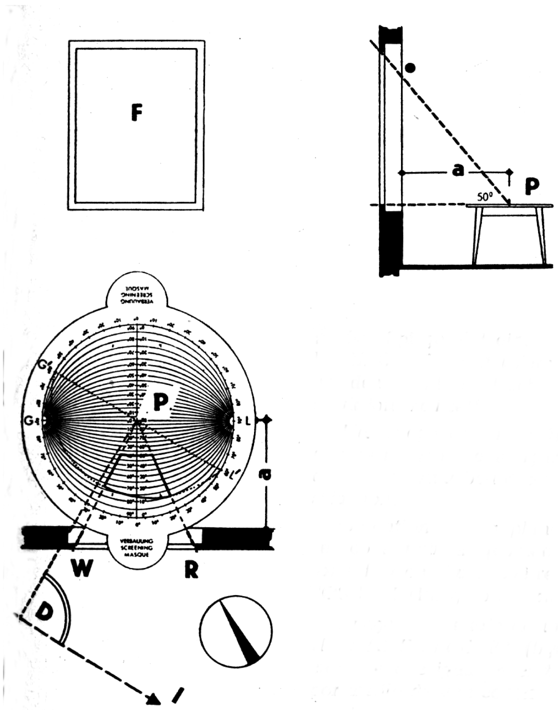
Picture of Horizontoscope with Acrylic halfdome, compass, and sun path chart



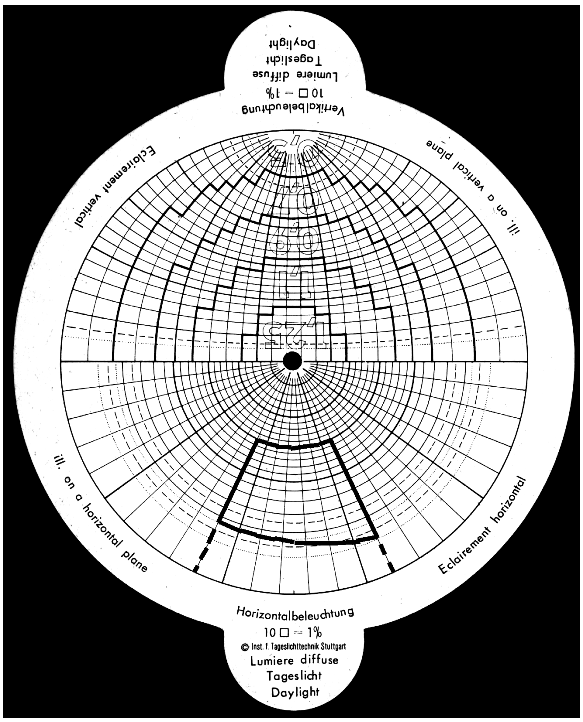
Sunshine duration for a considered point, obtained on site with the Horizontoscope



The projection of a window onto a screening chart is determined on the drawing board by geometrical construction



Determination of illuminance under an overcast sky on a horizontal plane, by evaluating the number of grids within the projected window. One grid element corresponds to 0.1 % daylight factor (only the direct sky component)



2.4.2 WALDRAM DIAGRAM, DIRECT SKY COMPONENT

Author / Source
P.J. Waldram

Subject
Determination of the direct sky component of the daylight factor.

Description
The method is based on a projection of half the sky hemisphere onto a grid, which is constructed such that equal areas of grid represent equal contributions from the sky to the illumination at considered points. The diagrams are available for different sky models (e.g. uniform sky, CIE overcast sky).
Taken from scaled room plans and sections, the areas of sky and outdoor obstructions visible from a reference point are drawn into the diagram. The area enclosed by these projection lines corresponds to the graphical solution of the integral formula for the calculation of the sky component based on a solid angle principle. The sky component is then obtained by evaluating the projection area (of a window) within the diagram.

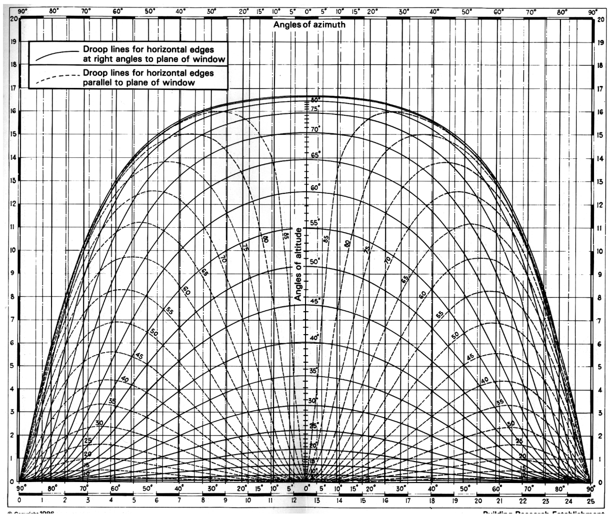
Discussion
Diagrams of this type allow to obtain the direct sky component for cases with complex outdoor obstruction and window shapes. Window transmission losses are taken into account. Additional methods have to be used to calculate the internal reflected component of the daylight factor (equation → tool 2.1.2, internal reflected component nomograms → tool 2.3.1).

References

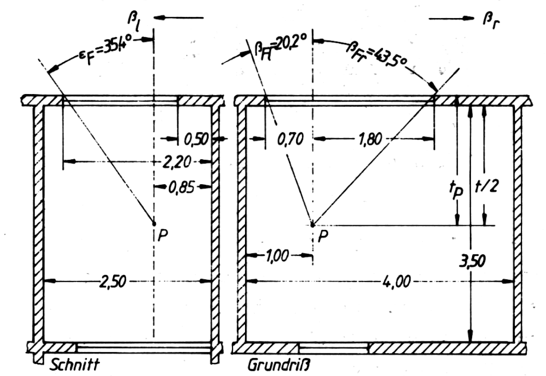
- P.J. Waldram, *A Measuring Diagram for Daylight Illumination*, B.T. Batsford Ltd, London, 1950.
- *Digest 309, Estimating daylight in buildings: Part 1*, BRE, Garston, GB, 1986.
- Udo Fischer, *Tageslichttechnik,* Verlagsgesellschaft Rudolf Müller GmbH, Köln, 1982.

Application Example:

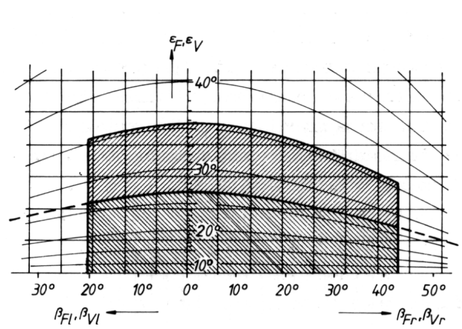
Waldram Diagram for a CIE overcast sky and vertically glazed aperture including corrections for glass losses



Room section and floor plan with angular projection from a selected reference point



Part of the diagram with the projected visible part of the sky (from the room above)



The doted line corresponds to a linear obstruction in front of the room. Around 19 grid elements of unobstructed sky are obtained and 26 of obstructed. One patch corresponds to 0.1 % direct sky component D_{sky}. Thus a direct sky component D_{sky} = **1.9 %** is obtained and assuming for the obstructed part **15 %** of the sky contribution a contribution of the obstruction of $D_{obstr.}$ = **0.39 %**. The only missing component is the internal reflected component (rf. to tools 2.1.2, 2.3.1).

2.4.3 DAYLIGHT AUTONOMY

Author / Source

Recommendation of the Swiss Lighting Association, Swiss Norm SN 418911

Subject

Determination of daylight autonomy.

Description

This tool provides for a rated task illuminance and a given daylight factor the minimum operating hours [%] during which a workplace can sufficiently and exclusively be lit with daylight. The considered working hours are from 7 a.m. to 5 p.m. (or 8 a.m. to 6 p.m.). The considered period is one year.

Discussion

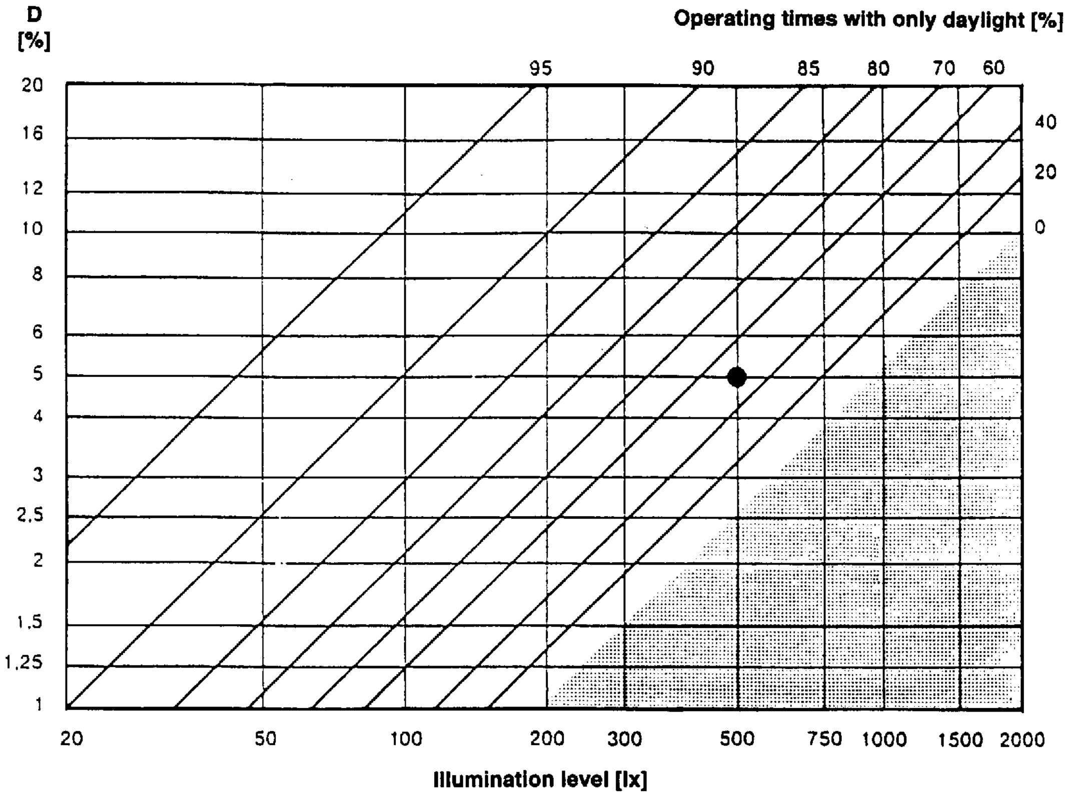
The diagram is designed for Swiss conditions, i.e. the daylight autonomy as function of daylight factor and rated illuminance is based on outside illuminances according to the CIE sky for Swiss latitudes. Nevertheless, it is easily possible to generate correspon-ding diagrams for other latitudes. Since the daylight factor is defined as the worst case, it can be assumed that the daylight autonomy under real skies will be better than the here obtained daylight autonomies. The chart represents values over a period of one year, thus averaged over all seasons.

References

- Recommendation of the Swiss Lighting Association, Swiss Norm SN 418911, Edited by Schweizerischer Elektrotechnischer Verein (SEV), CH-8008 Zürich, Seefeldstr. 301.

Application Example

Operating times [%] with only daylight for working hours as a function of the daylight factor and rated workplace illuminance



2.4.4 LIGHTING SWITCH-ON HOURS

Author / Source
M. Szerman, Fraunhofer Institute for Building Physics

Subject
Method for estimation of lighting switch-on hours based on daylight factor and local weather data sets.

Description
Although for clear and partly cloudy skies not applicable, the daylight factor is still the most used daylighting design parameter. This simplified method derives 4 boundary conditions for the relation between the daylight factor and artificial lighting switch-on hours. These constraints are obtained from local weather data sets and from working hours. For a known daylight factor at a lighting control point the switch-on hours and therefore the energy consumption of luminaires can be estimated.
Boundary conditions for switch-on hours are obtained as follows:

1. The upper limit, corresponding to a $\mathbf{D_1 = 0\ \%}$, is represented simply by the total sum of working hours in the considered period.
2. The lower limit is obtained by the time in the considered daily working intervals where the exterior horizontal illuminance falls below the desired workplace illuminance:

   $\mathbf{E_{outside} < E_{task}}$. This definition implies $\mathbf{D_4 = 100\ \%}$.
3. Lighting switch-on hours are only reduced if the illuminance through daylight exceeds at least once the desired control point illuminance. In order to obtain switch-off hours at all, the daylight factor thus has to be bigger than:

   $$\mathbf{D_2 = E_{task} / E_{max,clear\text{-}sky\ with\ sun}}\ .$$
4. Most of the time real sky conditions are some intermediate states between clear and overcast skies. From overcast skies thus a fourth condition can be derived:
   $\mathbf{D_3 = E_{task} / E_{max,\ overcast\ skies}}$. Switch-on hours for $\mathbf{D_3}$ are then obtained by subtracting the time, during which the constraint $\mathbf{E_{outside} > E_{task} / D_3}$ is fulfilled, from the total working hours.

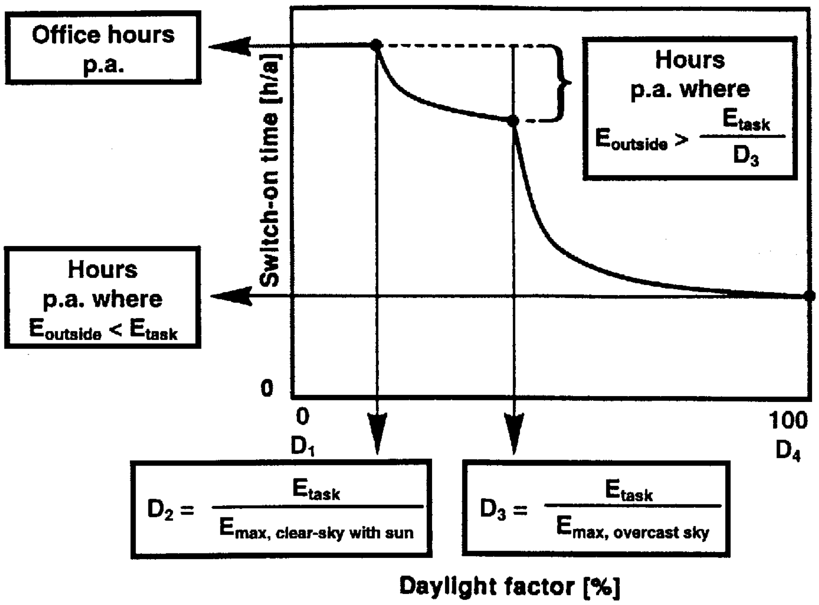
Discussion
All boundary conditions derived here are independent of room geometries. By evaluating for instance hourly local weather data, all 4 boundary conditions can approximately be determined. Modelling of the boundary conditions involves a number of uncertainties and assumptions. The use of this method should thus be restricted to quick estimates in early design stages.

References

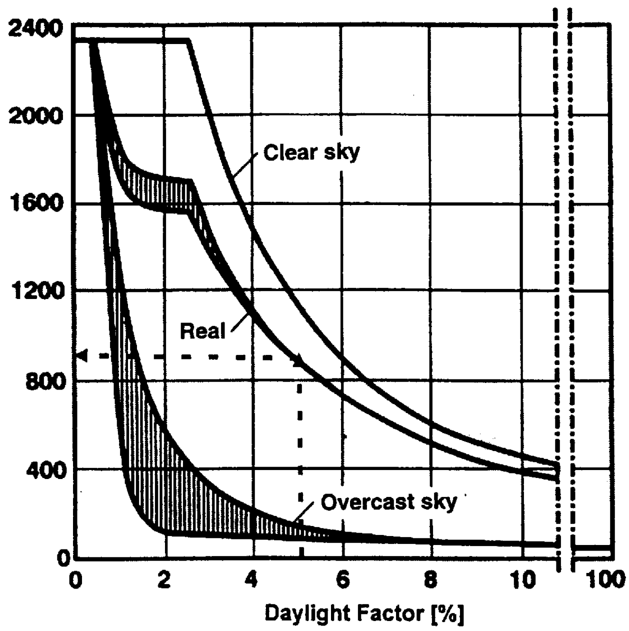
- M. Szerman, *„Effects of daylight utilisation on the energetic behaviour of office buildings“*, Ph.D. thesis, University Stuttgart, 1994.

Application Example:

General relation of daylight factor and switch-on hours of supplementary lighting



Relation of daylight factor and switch-on hours of supplementary lighting derived from paramter study for a fixed German location



Working hours are Monday - Friday from 7 a.m.-4 p.m. [8 a.m.-5 p.m.] without holidays. Task illuminance has been set to 500 lx. For a daylight factor of for instance 5 %, artificial lighting needs to be switched on for approximately 900 hours a year.

2.5.1 B.R.S. DAYLIGHT PROTRACTORS

Author / Source
A.F. Dufton, J. Longmore et. al.

Subject
Determination of the direct sky component at single reference points.

Description
The daylight protractor disks are directly applied within the room plans. A so-called primary protractor contains a daylight scale from which the direct component can be obtained. An auxiliary protractor holds a correction factor scale for finite window width (for opening angles less than 180° from a reference point). Special protractors hold both scales on one disk (rf. to the example). Numerous protractor sets for different types of skies (CIE standard overcast, uniform, and even clear skies) and differently inclined glazings (horizontal, vertical, as well as tilted) are available. The analytical formulae on which the method is based is the projected solid angle principle.

Discussion
The tool is very easy to handle. It was therefore for a long time one of the standard manual tools in daylighting design. It is quicker to use than corresponding grid methods, but on the other hand not capable of dealing with more complex shaped outside obstructions. For the calculation of the internal reflected components additional other methods have to be used (rf. equation → tool 2.1.2, internal reflected component nomograms → tool 2.3.1).

References

- J. Longmore, *BRS Daylight protractors*. HMSO, 1968.
- *Digest 309, Estimating daylight in buildings: Part 1*, BRE, Garston, GB, 1986.
- *Daylighting In Architecture, A European Reference Book*, James & James Ltd, London for the Commision of the European Communities, 1993.

Application Example

B.R.S Sky Component Protractor for Vertical Glazing for CIE Overcast Sky

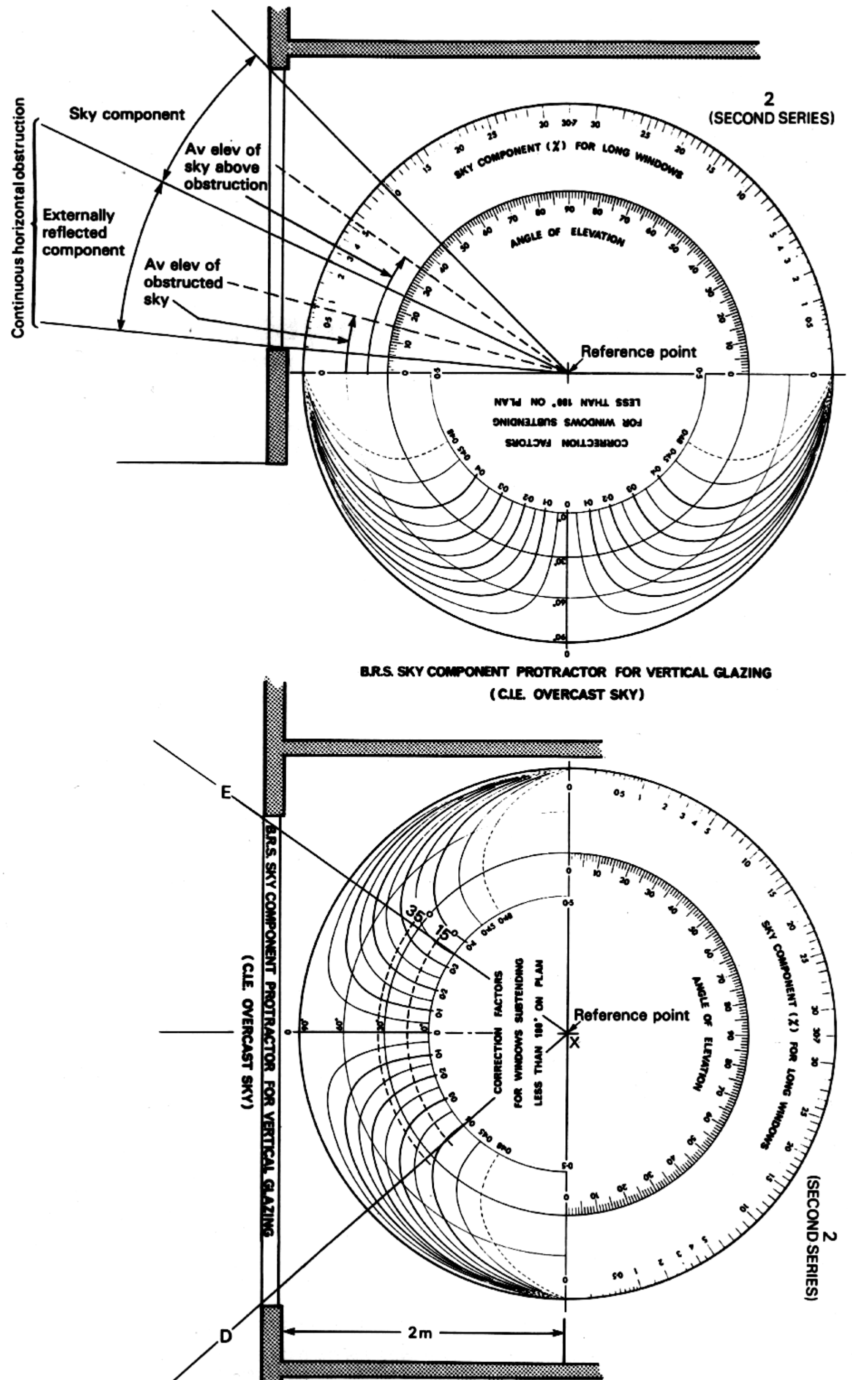


Fig 7 Building Research Station protrac

The B.R.S second series types allow to obtain the direct component (upper drawing) and the correction factor for finite window widths from one protractor disk. As displayed in the upper drawing the direct component can be separated into the sky component and an externally reflected component.

2.6.1 DAYLIGHT CALCULATIONS FOR SHOEBOX-TYPE ROOMS

Authors:
Lawrence Berkeley National Laboratory, USA;
Fraunhofer Institute for Building Physics, Germany

Subject
Daylight computer calculations for shoebox-type rooms.

Description
Integrated into the program package ADELINE, the method is based on a *simple input mode* to the program SUPERLITE. Menu-oriented, it allows for fast parametric descriptions of geometrically simple scenarios. Although limited to rectangular room geometries a number of parameters influencing lighting conditions can be specified. These include the definition of overhangs, support of artificial lighting, different placements of the room's daylight openings - either sidelit or rooflit, specification of up to 5 windows- and modelling of geometrically simple obstructions. Due to the integration into the ADELINE program system, all standard sky models can be simulated. Daylight factors, illuminances, and the geometric model can be graphically visualized.

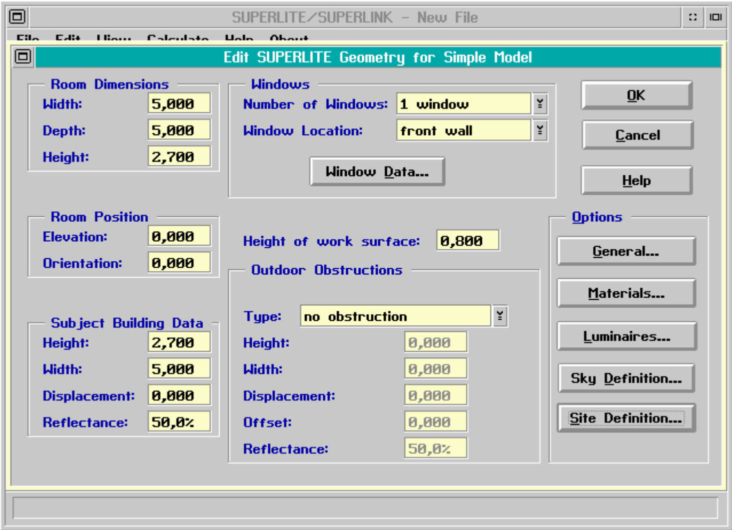
Discussion
The tool is well suited for fast parameteric studies at early design stages. The use of a CAD tool is not necessary. Based on calculations with the extensively validated program SUPERLITE 2.0, accurate results are obtained. With the ongoing work within IEA SHC TASK 21 the simple input module of the program system ADELINE will be extended to other geometries.

References

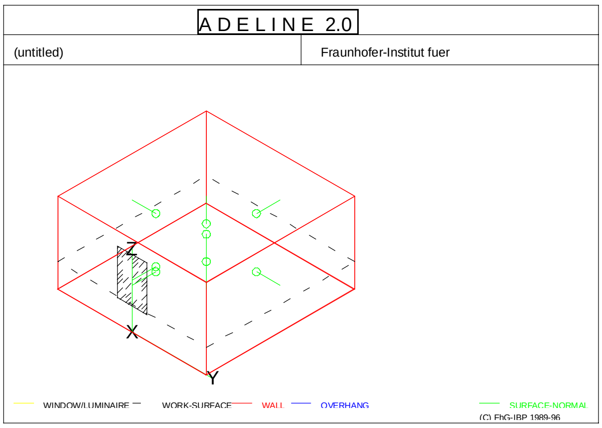
- Hans Erhorn, Jürgen Stoffel (Principal Editors): *ADELINE 2.0 User's Manual*, Fraunhofer Institute for Building Physics, Stuttgart, Germany.
- R. Hitchcock and W. Osterhaus: *SUPERLITE 2.0 User's Manual*, Lawrence Berkeley Laboratory, Report No. LBL-32946, 1993.

Application Example

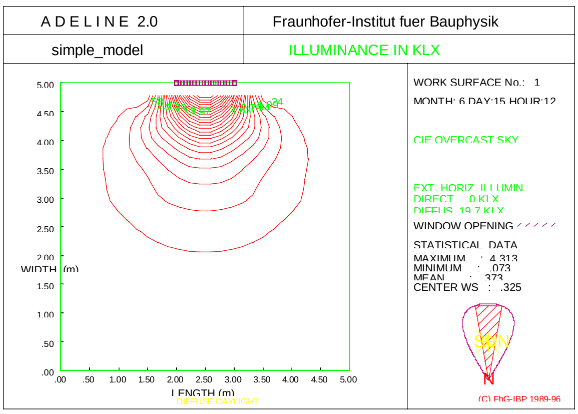
ADELINE / SUPERLITE Simple Model Input Menu



ADELINE / SUPERLITE Simple Model Input View



ADELINE / SUPERLITE Illuminances obtained for Simple Model



2.6.2 SHADOW AND REFLECTION ANALYSIS

Author / Source
Geoffrey Roy

Subject
Shadow and sunlight reflection analysis in the built environment.

Description
The tool may be used for shadow and reflection analysis at all scales, from the study of shadows cast by an eaves overhang, to shadow and reflection analysis in an urban precinct, which might contain many complex buildings. The integrated CAD module is designed according to the complexity of problems to be analyzed: allowing for fast menu driven scene generation, but also encorporating access to a formal command language for detailed modelling. For calculation of the sun position the program requires as input the time of day, day of year, geographical latitude and longitude of the site under investigation. The tool generates graphical output of the scene with superimposed shadow and reflection areas. The results from several computations (e.g. different times, dates) can be displayed on the model, either separately or superimposed. In this way the path of shadows or reflections during the day (or year) can be easily visualized and therefore analyzed.

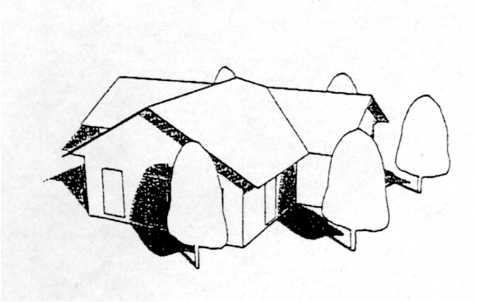
Discussion
The program runs under the operating system MS-DOS. It does not encorporate exact photometric models, therefore no values, like luminances or illuminances within the scene can be calculated.

References

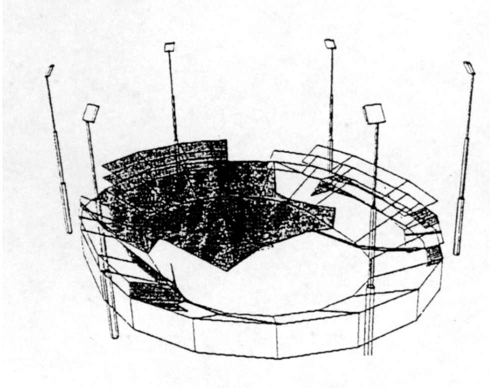
- SR, Shadow and Reflection Analysis, A system for IBM compatible PCs for modelling the built environment and the computation and display of shadows and reflection caused by sunlight, Geoffrey Roy, Murdoch University, Department of Engineering, South Street, Murdoch, Western Australia 6150, Australia.

Application Example

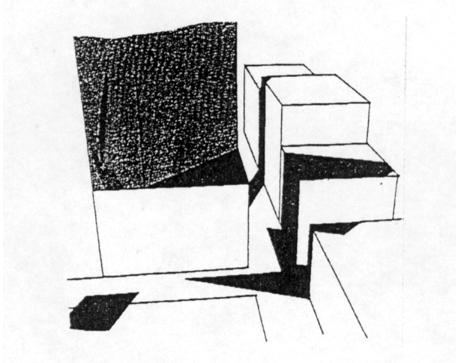
Shadows cast on a dwelling by eaves and trees



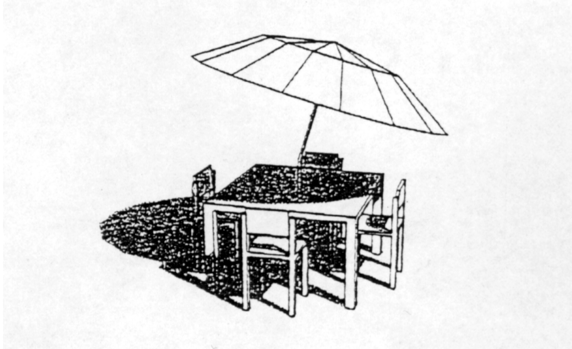
Shadows cast in a stadium from stand and lighting towers



Reflection study showing reflections from building onto street and adjacent buildings



A detail study of shadows under an umbrella



2.6.3 SPREADSHEETS: COLLECTION OF EQUATIONS & DIAGRAMS

Authors / Source
Institut für Licht- und Bautechnik, Köln
Fraunhofer Institute for Building Physics, Stuttgart

Subject
MS-EXCEL spreadsheets for basic equations commonly used in daylighting.

Description
The astronomical equations for the calculation of the sun position and definitions of CIE standard sky models have been transformed into Excel - spreadsheets. As a function of time and location the sun position, the outside illuminances, luminances at specified sky positions etc. can be obtained. Daylight autonomy for a given daylight factor can be calculated. Diverse diagrams are included.

Discussion
With the widespread use of MS-Excel the tool provides a convenient collection of spreadsheets for fast access to often required data, especially on the sky models.

References
- ILB, Institut für Licht- und Bautechnik an der Fachhochschule Köln, Betzdorferstr. 2, 50679 Köln.
- Fraunhofer Institute for Building Physics, Nobelstraße 12, 70569 Stuttgart.

Application Example:

Chart providing the sun position (altitude and azimuth) for a given location at different times of the year

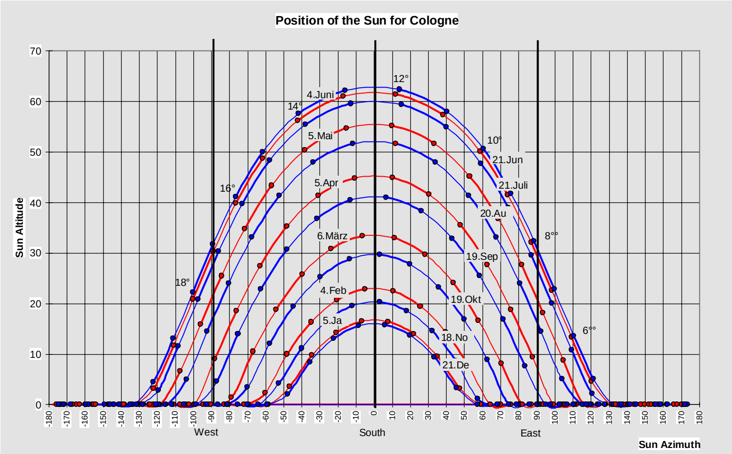


Chart providing the horizontal external illumin-ance for different sky models at a given location

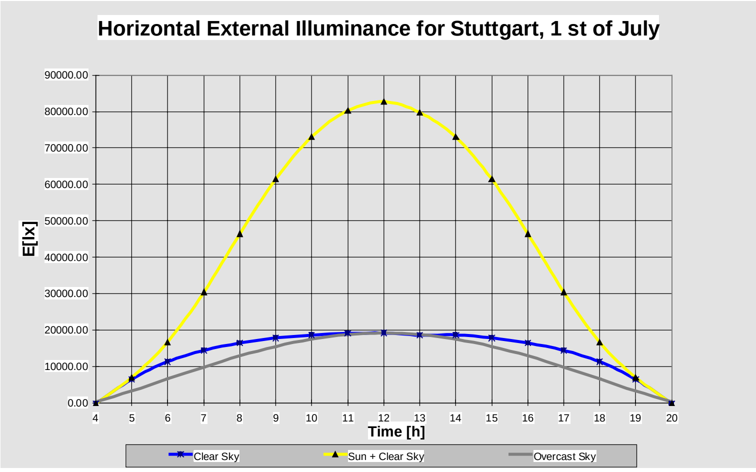
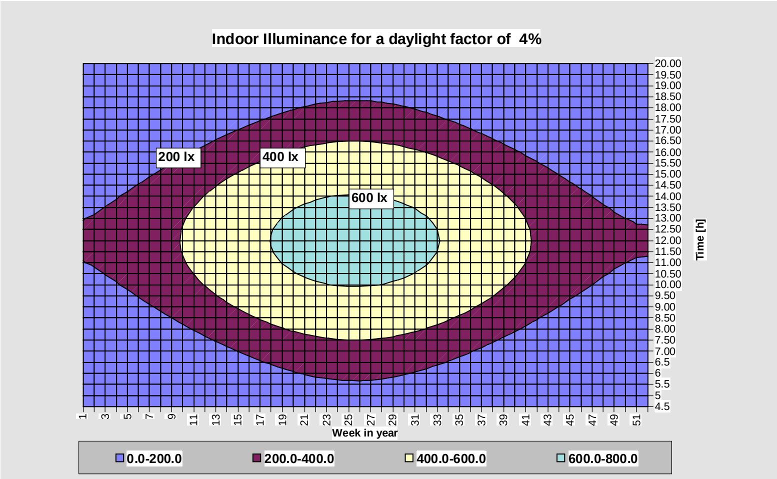


Chart for the determination of daylight autonomy. For a given daylight factor the times in a year are specified, when a certain indoor illuminance is reached



2.6.4 SOLAR LIGHT FACTORS FOR DYNAMIC LIGHTING CONTROL

Authors:
Erwin Petersen, Kjeld Johnsen, Karl Grau, Danish Buildding Research Institute

Subject
Model for calculation of illuminance level at reference point based on solar irradiance on windows. The model is integrated in the thermal design tool tsbi3 and can easily be integrated in other tools. The calculated daylight illuminance level is used as the reference for control of the artificial lighting, hour by hour, or time step by time step, corresponding to the weather data used for simulation.

Description
The daylighting model is based on Solar Light Factors (SF) which describes the illuminance at a spot on a surface in the room divided by the illuminance outside, on the plane of the glazing of the window. For each window in a room (or group of windows) 3 solar light factors are defined, determined for 3 contributions from the solar radiation:

the direct solar radiation from the sun:	(SF1)
diffuse radiation from the sky:	(SF2)
diffuse, reflected radiation from the ground (and surroundings):	(SF3)

A fourth solar light factor , SF4, is defined for use of solar shading devices (curtains, venetian blinds etc.). This factor 'overwrites' the other factors when the shading is drawn for the windows, while a mixed case is considered when the shading is only used for part of the window(s).

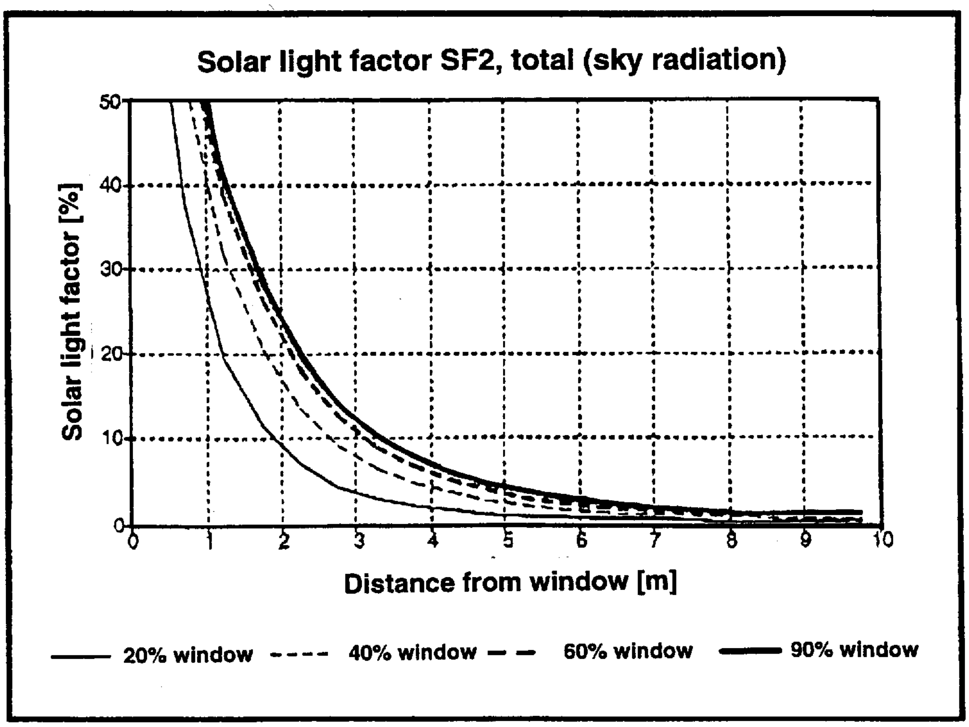
Discussion
Compared to the traditional approach of using the Daylight Factor, the described model has the advantage that it can be applied to any type of sky and therefore can also be used in dynamic simulations.
As implemented in tsbi3, the model is limited to calculation of the illuminance in one reference point, usually defined on the working plane. Another limitation of the method is that the three (or four) Solar Light Factors must be determined by other means, e.g. from diagrams or tables. In principle the method can be applied to any room configuration but for calculation of complex rooms, it requires another tool for calculation of the SFs. The example shows a diagram for the determination of the solar light factor SF2 with the distance from the window(s) in a 10 m deep room, and for different 'window-percentages', i.e. % of the facade.
The described approach to daylight prediction at a given reference point of a room has proven to give reliable results, thus providing the practitioners with an integral tool which in one calculation can simulate the thermal, the daylighting, as well as the energy performance of the buildings.

References

- tsbi3. Computer program for thermal simulation of buildings. User's Guide. K. Johnsen and K. Grau, The Danish Building Research Institute, Horsholm, Sept. 1994.

Application Example

Curves for the determination of the solar light factor SF2 as function of distance from the window and window percentage (of facade)



2.6.5 DIAL: QUALITATIVE & QUANTITAVE DAYLIGHTING DESIGN

Authors:
Bernard Paule, Jean-Louis Scartezzini, École Polytechnique de Lausanne

Subject
Tool for the early design process, based on qualitative information.

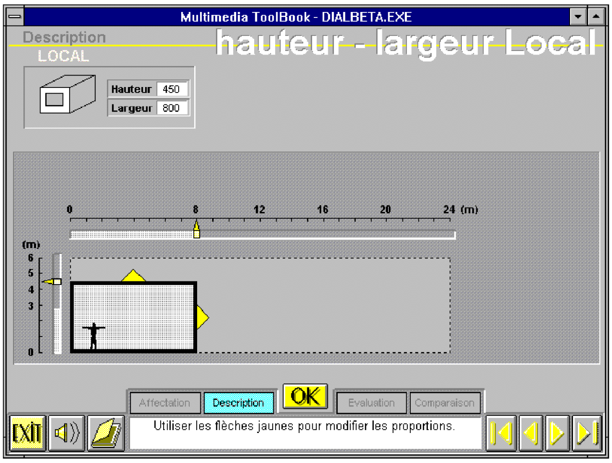
Description
Beside quantitative estimation of daylight factors and daylight autonomy the tool provides qualitative diagnosis from expert knowledge translated into fuzzy logic rules. The tool is embedded in an easy to use graphical environment requesting as input mainly graphical and linguistic information.

Discussion
The simulation tool requires little -almost none- learning time. No specific knowledge on daylighting is required, which means that it can be applied quickly in the very decisive early design phase also by people not deeply involved in lighting technology. The speed of the whole procedure is also particularly well adapted for carrying out parametric studies. So far only rectangular shaped rooms are supported, an extension to other geometries is intended. The program is adapted to Swiss standards, but it is to be put on a broader international basis (also including a translation to English).

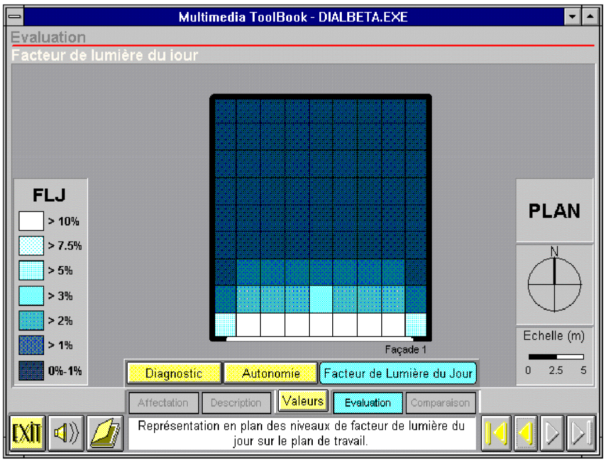
References
- B. Paule, R. Compagnon, J.-L. Scartezzini 1995: Towards a new daylighting design computer-tool, Proceedings of the Right-Light Three conference, Newcastle upon Tyne, England.

Application Example

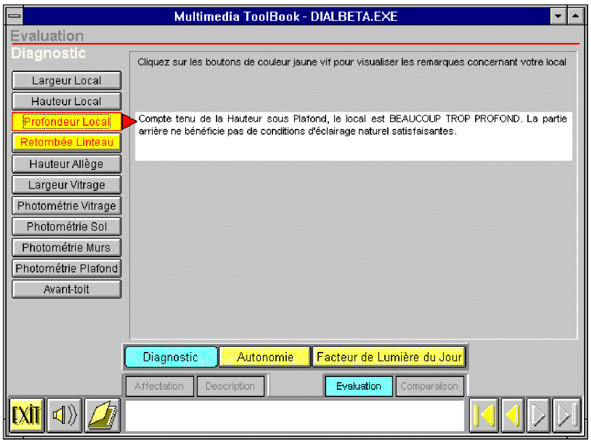
Simple interactive graphical specification of input parameters. Example for the specification of room height and room depth.



The tool allows for a fast calculation of the daylight factor. In addition the daylight autonomy can be displayed.



A genuine feature of the program is the display of qualitative comments on the daylight study performed. For the example displayed here, the room depth was way to big.



2.7.1 TYPOLOGICAL STUDY OF VARIOUS TEST ROOMS

Authors / Source

Y. Golay, L. Deschamps, D. Limberis, I. Vogel, J. Dahinden, A. Tschumi.

Subject

Typological study on the influence of main daylighting design parameters.

Description

The tool provides fast accessible graphical as well as numerical information on the influence of some main parameters on the illumination and visual appearance of indoor spaces. More than 50 cases have been examined, with modified types, dimensions, positions, and inclines of daylight openings. The provided graphical information contains isometric drawings of the rooms, graphs illustrating direct solar penetration for summer and winter conditions (at solstice), as well as a photorealistic visualisation of the test room for an overcast day. The visualization and selected characteristic physical numbers (e.g. daylight factor near the window, 3 meters from the window, portion of the surface area falling below a daylight factor of 2 %) have been simulated using the lighting simulation software RADIANCE. The influence of the various daylight openings on the light distribution in the middle of the room is related to a reference case. Evaluations concerning visual comfort are included.

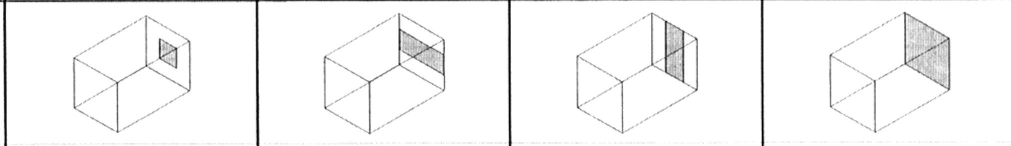
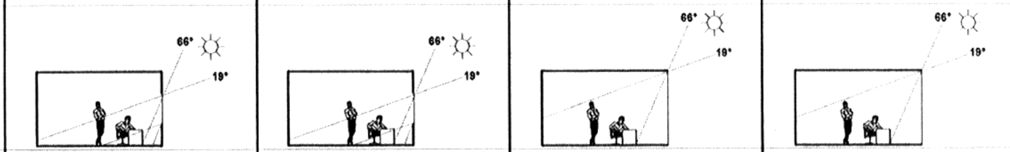
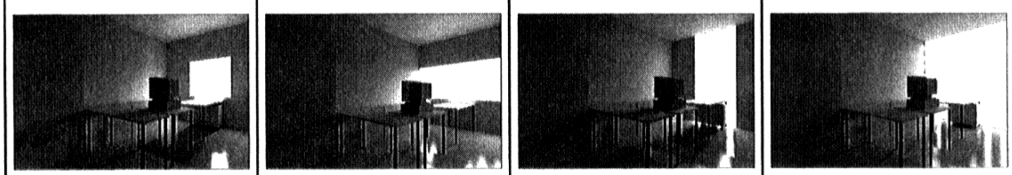
Discussion

Not only numerical but also visual information is included. This gives a fast understanding of the visual perception of daylight in rooms. A powerful simulation tool has been used to show the strong impact of simple modifications of basic daylighting design parameters like window size and placement. The study is not suited for thorough numerical analysis; it should rather be understood as design guide for architects and building designers in the early conception of a building. The study has been performed for Swiss conditions, thus some of the provided information is restriced to Swiss latitudes, climates, and regulations.

References

- Developed in the LUMEN Program, Grojet CERS 2264.2, Projet NEFF 435.3, Switzerland, Y. Golay, L. Deschamps, D. Limberis, I. Vogel, J. Dahinden., A. Tschumi. Edited by EPFL, CH-1015, Lausanne, Switzerland

Application Example

			T1	T2	T3	T4
Architecture	Axonométrie					
	été / Lumière directe / hiver					
	Lumière diffuse					
	I_o / C.c.		9.6% / 90	24% / 90	24% / 0	60% / 0
	Vue		Cadrée	Panoramique	Centrée en hauteur	Totale
Energie	FLJ max		22.2% à 0.5m	27.6% à 0.5m	26.4% à 0.5m	37.3% à 0.5m
	Surface < 2%		6/10	4/10	3/10	0/10
	FLJ à 3m		1.03%	2.26%	2.44%	5.66%
	*Variation en % à 3m		100%	+120%	+137%	+450%
Confort visuel	Poste 1	Ergorama	1/14	1/10	1/7	1/6
		Panorama	1/83	1/60	1/64	1/30
	Poste 2	Ergorama	1/14	1/10	1/13	1/10
		Panorama	1/27	1/19	1/20	1/16

I_o = indice d'ouverture C.c. = Contrecoeur * Variation du FLJ en % par rapport à T1

Exerpt from the typological study showing the impact of different window sizing and positioning on lighting conditions. Beside graphical information partly obtained from simulations performed with the program RADIANCE, basic numerical information is provided.

2.8.1 ARTIFICIAL SKY / ARTIFICIAL SUN

Authors / Source
Divers, rf. to summary of institutions having testing facilities.

Subject
Scale model analyses under artificial skies and suns allows for simple but detailled analysis of daylight performance.

Description
Assuming that the photometric properties of surfaces and transparent daylight openings are modelled correctly, buildings can be scaled down and be investigated photometrically correct under artificial skies and suns. Unlike with thermal, acoustic and structural models, no scaling corrections for lighting models are required.
The design of artificial skies allows to model different sky luminance distributions. Sensors placed within the models monitor illuminance or luminances. Daylight factors can be obtained by placing a second sensor outside the model.
In addition artificial suns allow to perform shadow and reflection analysis by the simulation of direct sunlight for every time of the year.

Discussion
Many architects work with scale models. Numerous of these models are designed to illustrate the architectural intentions rather than to evaluate lighting design photometrically correct. Nevertheless some models are suited for direct use, especially the impact of direct sunlight under artificial skies can be assessed easily. Artificial skies and suns allow to perform simple parametric studies quickly. As a limitation it has to be stressed, that detailled models can be very expensive. For changes in the building design, also the model has to be readjusted. For most practioners it is not economical to construct own test stands. Therefore a selected list of testing facilities is provided.

References
- rf. to list of artificial skies, next page.

Application Example

Example of artificial sky
(at Fraunhofer Institut for Building Physics)

Example of artificial sun
(at Fraunhofer Institut for Building Physics)

Aritificial skies and suns are (among others) available at these institutes participating in Task 21:

Country	Institute	Artificial Sky	Artificial Sun	Contact
Austria	Bartenbach Lichtlabor	Yes	Yes	Lichtplanung Bartenbach Rinnerstraße 14, A-6071 Aldranz / Innsbruck
Germany	Fraunhofer Institute for Building Physics	Yes	Yes	Fraunhofer Institute for Building Physics Dept. of Heat Technology, Nobelstr. 12, D-70569 Stuttgart
	Technical University Berlin	Yes		TU Berlin, Fakultät für Architektur, Straße des 17. Juni 152, Berlin
Great Britain	BRE	Yes	Yes	Building Research Establishment, Lighting Section, Bucknalls Lane, UK-Garston, Watford WD27JR
Netherlands	TNO	Yes	Yes	CBO-TNO-TUE Centre for Building Research P.O. Box 513 NL-MB Eindhoven
Switzerland	EPFL - LESO	Yes	Yes	LESO-PB / EPFL, CH-1015, Lausanne
U.S.A	LBNL	Yes	Yes	Lawrence Berkeley Laboratory, Window and Daylighting Group, Berkeley, CA 94720

3 CHARACTERIZATION OF THE REVIEWED TOOLS

The tabular overview on the next page, characterising the tools according to a set of usage related attributes, allows for a problem-sensitive selection of tools:

General The table first of all gives a general judgement of the *Flexibility* in the application of the tools. The *Application* of some tools is restricted to *Local* climates or specific national regulation, others can be used anywhere. Some tools like the Horizontoscope are globally applicable, nevertheless require for instance projection charts dependent on the latitude. In such cases the *Global* as well as *Local* attributes are checked.

Input The input required by the diverse methods has been characterised acoording to *Sky*, *Geometric Space* and *Windows* type treatable.

Output The classification of tool output is subdivided into the basic *Method* employed (weather it is *Single Stage* method, therefore the tool delivers the desired output directly or weather for instant for obtaining the daylight factor multiple steps as there are the *Direct Component* and the *Interreflected Component* have to be calculated) and the *Type* of output to be obtained.

Software It is checked weather the reviewed tools are available or can be transformed into *Spreadsheets* with reasonable effort. Computer tools are classified according to *Operating System* and the *Graphical Interface*.

		Formulae		Tables		Nomograms		Diagrams				Protrac-tors	Computer Tools					Typo-logy	Scale Models
		2.1.1	2.1.2	2.2.1	2.2.2	2.3.1	2.3.2	2.4.1	2.4.2	2.4.3	2.4.4	2.5.1	2.6.1	2.6.2	2.6.3	2.6.4	2.6.5	2.7.1	2.8.1
General:																			
Flexibility	Maximum							■				■	■	■			■	■	■
	Medium	■	■		■	■	■		■						■	■			
	Minimum			■						■	■								
Appli-cation	Global (any site)	■	■		■	■	■	■	■			■	■	■	■	■	■		■
	Local			■				■	■	■	■	■					■		
Input:																			
Sky	Clear Sky					■		■	■		■	■	■	■	■	■		■	■
	CIE Overcast	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■
	Uniform								■			■	■						■
Geometric Space	Simple Space (Rect.)	■	■	■	■	■						■	■					■	■
	Complex Space							■	■	■	■	■	(■)	■		■	■	■	■
	Atria						■						(■)						■
	Simple Obstruction		■	■		■						■	■						■
	Complex Obstruction							■	■	■	■		(■)	■			■	■	■
Windows	Vertical		■	■		■	■	■	■	■	■	■	■			(■)	■	■	■
	Sloped					■		■	■	■	■	■	(■)			(■)	■	■	■
	Rooflights	■	■		■	■		■		■	■	■	■			(■)	■	■	■
Output:																			
Method	Direct Component							■	■			■							
	Interrefl. Component		■			■													
	Single Stage	■		■	■		■			■	■		■				■	■	■
Type	Daylight Factor / Illum.	■	■		■	■	■	■	■			■	■				■	■	■
	Shadow Analysis							■					(■)	■					■
	Daylight Autonomy & Light Switch-on hours									■	■		(■)		■	■	■		
	Visual Comfort							■					(■)					■	■
Software:																			
Spread-sheet	Yes														■				
	Transformation Possible	■	■																
System	MS-DOS												■	■					
	Windows												■		■	■	■		
Graphical Interface	Graphical Input												■	■		■	■		
	Graphical Output												■	■	■	■	■		
	Visualisation												■	■			■		

(■): Referring to computer tools: can also be performed with the characterised software, but is not considered simple.

4 LIST OF CONTACT PERSONS

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5 IEA INFORMATION

OVERVIEW OF THE IEA AND THE SOLAR HEATING AND COOLING AGREEMENT

INTERNATIONAL ENERGY AGENCY

The International Energy Agency, founded in November 1974, is an autonomous body within the framework of the Organization for Economic Cooperation and Development (OECD) which carries out a comprehensive program of energy cooperation among its 24 member countries. The European Commission also participates in the work of the Agency.

The policy goals of the IEA include diversity, efficiency and flexibility within the energy sector, the ability to respond promptly and flexibly to energy emergencies, the environmentally sustainable provision and use of energy, more environmentally-acceptable energy sources, improved energy efficiency, research, development and market deployment of new and improved energy technologies, and cooperation among all energy market participants.

These goals are addressed in part through a program of international collaboration in the research, development and demonstration of new energy technologies under the framework of 40 Implementing Agreements. The IEA's R&D activities are headed by the Committee on Energy Research and Technology (CERT) which is supported by a small Secretariat staff in Paris. In addition, four Working Parties (in Conservation, Fossil Fuels, Renewable Energy and Fusion) are charged with monitoring the various collaborative agreements, identifying new areas for cooperation and advising the CERT on policy matters.

IEA SOLAR HEATING AND COOLING PROGRAM

The Solar Heating and Cooling Program was one of the first collaborative R&D agreements to be established within the IEA, and, since 1977, its Participants have been conducting a variety of joint projects in active solar, passive solar and photovoltaic technologies, primarily for building applications. The nineteen members are:

Australia	Japan
Austria	Mexico
Belgium	The Netherlands
Canada	New Zealand
Denmark	Norway
European Commission	Spain
Finland	Sweden
France	Switzerland
Germany	United Kingdom
Italy	United States

A total of 26 projects or "Tasks" have been undertaken since the beginning of the Solar Heating and Cooling Program. The overall program is monitored by an Executive Committee consisting of one representative from each of the member countries. The leadership and management of the individual Tasks are the responsibility of Operating Agents.

These Tasks and their respective Operating Agents are:

*Task 1: Investigation of the Performance of Solar Heating and Cooling Systems - Denmark
*Task 2: Coordination of Research and Development on Solar Heating and Cooling - Japan
*Task 3: Performance Testing of Solar Collectors - Germany/United Kingdom
*Task 4: Development of an Insulation Handbook and Instrument Package - United States
*Task 5: Use of Existing Meteorological Information for Solar Energy Application - Sweden
*Task 6: Solar Systems Using Evacuated Collectors - United States
*Task 7: Central Solar Heating Plants with Seasonal Storage - Sweden
*Task 8: Passive and Hybrid Solar Low Energy Buildings - United States
*Task 9: Solar Radiation and Pyranometry Studies - Canada/Germany
*Task 10: Solar Material Research and Testing - Japan
*Task 11: Passive and Hybrid Solar Commercial Buildings - Switzerland
*Task 12: Building Energy Analysis and Design Tools for Solar Applications - United States
*Task 13: Advanced Solar Low Energy Buildings - Norway
*Task 14: Advanced Active Solar Systems - Canada
Task 15: Not initiated
*Task 16: Photovoltaics in Buildings - Germany
*Task 17: Measuring and Modelling Spectral Radiation - Germany
*Task 18: Advanced Glazing Materials - United Kingdom
*Task 19: Solar Air Systems - Switzerland
*Task 20: Solar Energy in Building Renovation - Sweden
Task 21: Daylighting in Buildings - Denmark
Task 22: Building Energy Analysis Tools - United States
Task 23: Optimization of Solar Energy Use in large Buildings - Norway
Task 24: Solar Procurement - Sweden
Task 25: Solar Assisted Cooling Systems for Air Conditioning of Buildings (Task Definition Phase)
Task 26: Solar Combisystems - Austria

**Completed*